

DOCUMENT RESUME

ED 108 602

IR 002 113

AUTHOR McClain, Janis; Smith, Edward L.
TITLE An Information Processing Approach to Skills Analysis.
INSTITUTION Southwest Regional Laboratory for Educational Research and Development, Los Alamitos, Calif.
REPORT NO SWRL-TN-2-72-49
PUB DATE 31 Oct 72
NOTE 32p.
EDRS PRICE MF-\$0.76 HC-\$1.95 PLUS POSTAGE
DESCRIPTORS Decision Making; Educational Development; Educational Innovation; Educational Strategies; Elementary School Students; *Information Processing; *Instructional Design; Learning Processes; Science Education; *Skill Analysis; Systems Approach; *Systems Concepts; Task Performance; Teaching Methods

ABSTRACT

An approach to skills analysis is described in which strategy and processing skills sufficient for task performance are represented as an information-processing routine. Each step in the routine is viewed as a utilization of a processing mechanism or primary process. Definitions of these processes represent hypotheses about the psychological nature of the mechanisms involved in carrying out the task using the selected strategy. Important advantages of this approach are discussed and illustrated with preliminary processing routines for simple description tasks. The psychological interpretation of the routines is illustrated with the definition of selected primary processes. (Author/SK)

* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *

ED108602



I R

SOUTHWEST REGIONAL LABORATORY TECHNICAL NOTE

DATE: October 31, 1972

NO: TN-2-72-49

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

AN INFORMATION PROCESSING APPROACH TO SKILLS ANALYSIS

Janis McClain and Edward L. Smith

ABSTRACT

An approach to skills analysis is described in which a strategy and processing skills sufficient for task performance are represented as an information processing routine. Each step in the routine is viewed as a utilization of a processing mechanism or primary process. Definitions of these processes represent hypotheses about the psychological nature of the mechanisms involved in carrying out the task using the selected strategy. Important advantages of this approach are discussed and illustrated with preliminary processing routines for simple description tasks. The psychological interpretation of the routines is illustrated with the definition of selected primary processes.

4R 002 113

AN INFORMATION PROCESSING APPROACH TO SKILLS ANALYSIS

Janis McClain and Edward L. Smith

In an effort to establish an appropriate framework for the design of science instruction, Smith (1972) has identified several networks of interrelated analytic concepts. These analytic networks represent abstractions of the structure of specialized conceptual systems characteristic of a discipline. Each network is associated with a set of tasks generated from the components of the network (i.e., the analytic concepts). Tasks, or performance requirements described in terms of observable inputs and outputs, are differentiated from the hypothetical skills which underlie performance of the task. Shared underlying skills reveal the behavioral relations between tasks and allow predictions of transfer between tasks; if a skill or group of skills is involved in each of two tasks, the learning of one task should facilitate the learning of the other. Thus, for a given task domain, the identification of skill substructures is useful for designing instruction with task arrangements promoting transfer. Once skills are identified, it is possible to choose enroute tasks and sequence instruction so that early tasks have skill components which are involved in later and more complex tasks (Bessemmer & Smith, 1972).

The present paper discusses an information processing method for identifying skills and illustrates the application of this method to selected tasks important in the primary science curriculum. This approach, analogous to that utilized in computer programming,

enables one to identify processing mechanisms which are sufficient for successful task performance. A task routine is prepared consisting of a sequence of processing steps and decision points. Each processing step is either a primary process, taken as a primitive functional unit defined in terms of input-output relations, or a secondary process, itself defined in terms of primary processes. Many primary processes are closely related to fundamental processes studied by psychologists. As such, they represent plausible hypotheses based on current psychological knowledge. Others may represent more complex behavioral sequences which, because of their common occurrences in the everyday life of children, need not be further analyzed, at least for the purposes of the present paper.

The actual preparation of the processing routines takes place in two stages. In the first phase, preliminary routines are designed which specify the strategy and the general nature of the processing steps. Several examples of such routines are described in the paper. Many decisions about the adequacy of strategies can be made at this level, including the applicability of the strategy to a content domain. Once such criteria have been fulfilled, a second phase of analysis is entered in which the processing steps are given a psychological interpretation. This phase is illustrated in the last section of the paper.

The tasks selected to illustrate the skills analysis approach are associated with the variable-value analytic network. This network involves the entities which are the objects of study in a

given discipline and the characteristics or properties used in studying them. The principal components of this network are:

elements -	the entities (e.g., objects, events, constructs, symbols, etc.)
variables -	the characteristics or properties of elements (e.g., weight, color) which are used to describe or otherwise study elements
values -	the terms assigned to elements for a given variable (e.g., rectangular, red)
observation/measurement - procedure	that procedure which, for a given variable, results in the extraction of value information about an element.

For this network four types of tasks have been identified: description, comparison, seriation, and sorting (or single variable classification) tasks. For each task type, terminal or outcome tasks have been identified. The three description outcome tasks have been selected for the present illustration.

Table 1 (taken from Smith 1972) summarizes the three description outcome tasks in terms of given and required components and illustrates each task with a sample item. For some routines, blocks of several steps have been differentiated from other steps and grouped together as subroutines. These may recur in routines for several different tasks. Figures 1-5 diagram processes involved in the description routines and subroutines. As will be discussed later, the specific processing steps involved in a given task are influenced by the kinds of systemic and particular content of that task. The routines diagrammed here are appropriate for discrete object elements and

TABLE 1

SIMPLE DESCRIPTION TASKS

Task Name	Given Input	Required Output	Sample Item
Element Identification	a set of <u>elements</u> a <u>value</u> for a variable	an <u>observation/measurement</u> <u>procedure</u> for the variable an <u>element</u> described by the given value	Given samples of salt, sugar, flour, sand, and chalk. "Which substance is soluble in water?"
Directed Description	an <u>element</u> a <u>variable name</u>	an <u>observation/measurement</u> <u>procedure</u> for the named variable a value for the named variable which describes the given element	Given a mineral specimen. "Determine and report the hardness of this rock."
Nondirected Description	an <u>element</u>	an <u>observation/measurement</u> <u>procedure</u> for a variable a <u>value</u> describing the given element on that variable (multiple cycles may be required)	Given a leaf specimen. "Describe this leaf as completely as you can."

qualitative variables for which the relevant features can be obtained through simple perceptual observation.

PROCESSING ROUTINES FOR DESCRIPTION OUTCOME TASKS

The nondirected description task, represented by the item shell, "Describe this object in as many ways as you can," requires an exhaustive description of the object in terms of variables whose choice and number are determined by the child. An overview of the processing steps involved in this task is diagrammed in Figure 1. Two subroutines are identified whose steps are diagrammed in Figures 2 and 3. In brief, the nondirected description task routine requires recall of a variable and its observation/measurement procedure from memory, and the subsequent execution of the procedure and reporting of obtained results. These latter subroutines involve the identification of standards with which the element may be compared. These standards may either be recalled or be available in the environment of the child as, for example, in a classroom situation where color samples are displayed (see Figure 2). For qualitative variables the child must compare the element to each standard until a matching standard and its value are identified (Figure 2). In the nondirected description task, the only given component is the element. The child must supply from memory the variable, value and observation/measurement procedure. Furthermore he must repeat the routine until his supply of applicable variables is depleted (Figure 1).

The directed description task (see Figure 4, and subroutines of Figures 2 and 3) represented by the item shell, "Describe the (variable

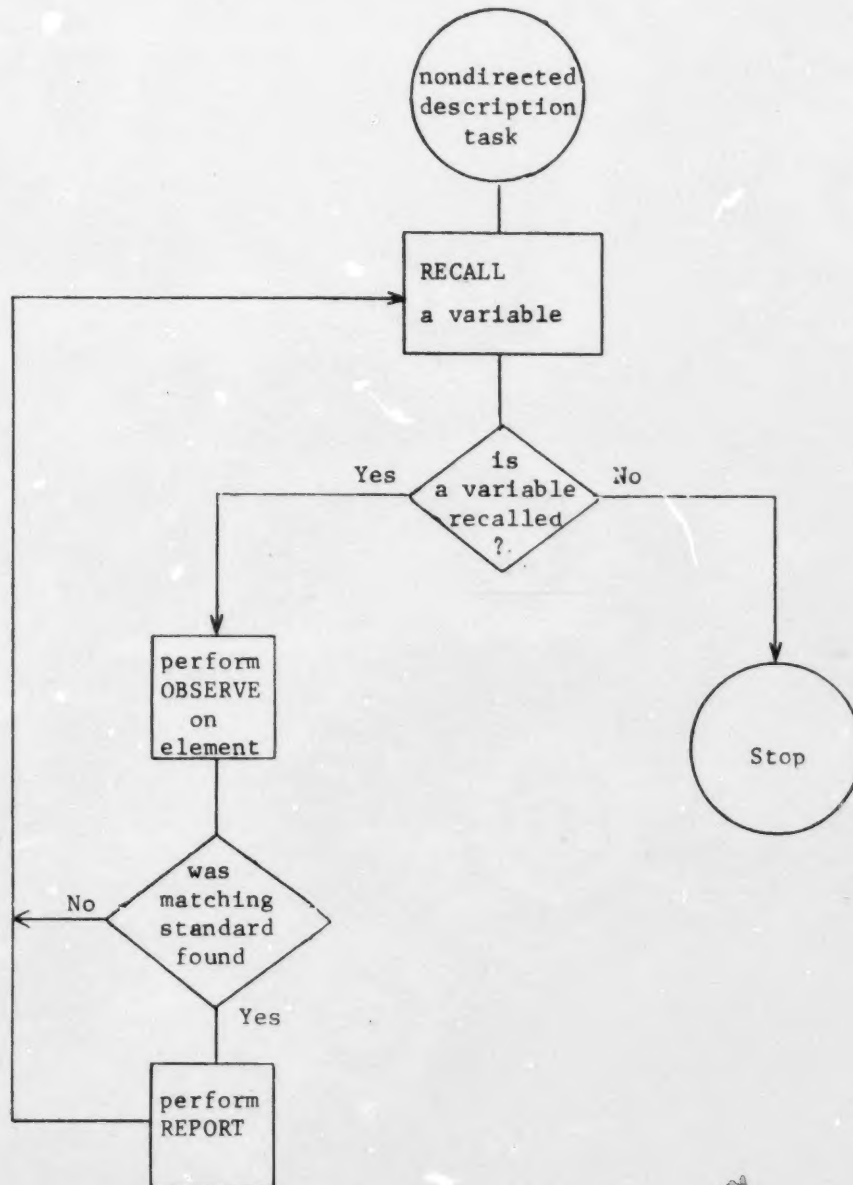


Figure 1. Processing routine for the nondirected description task.

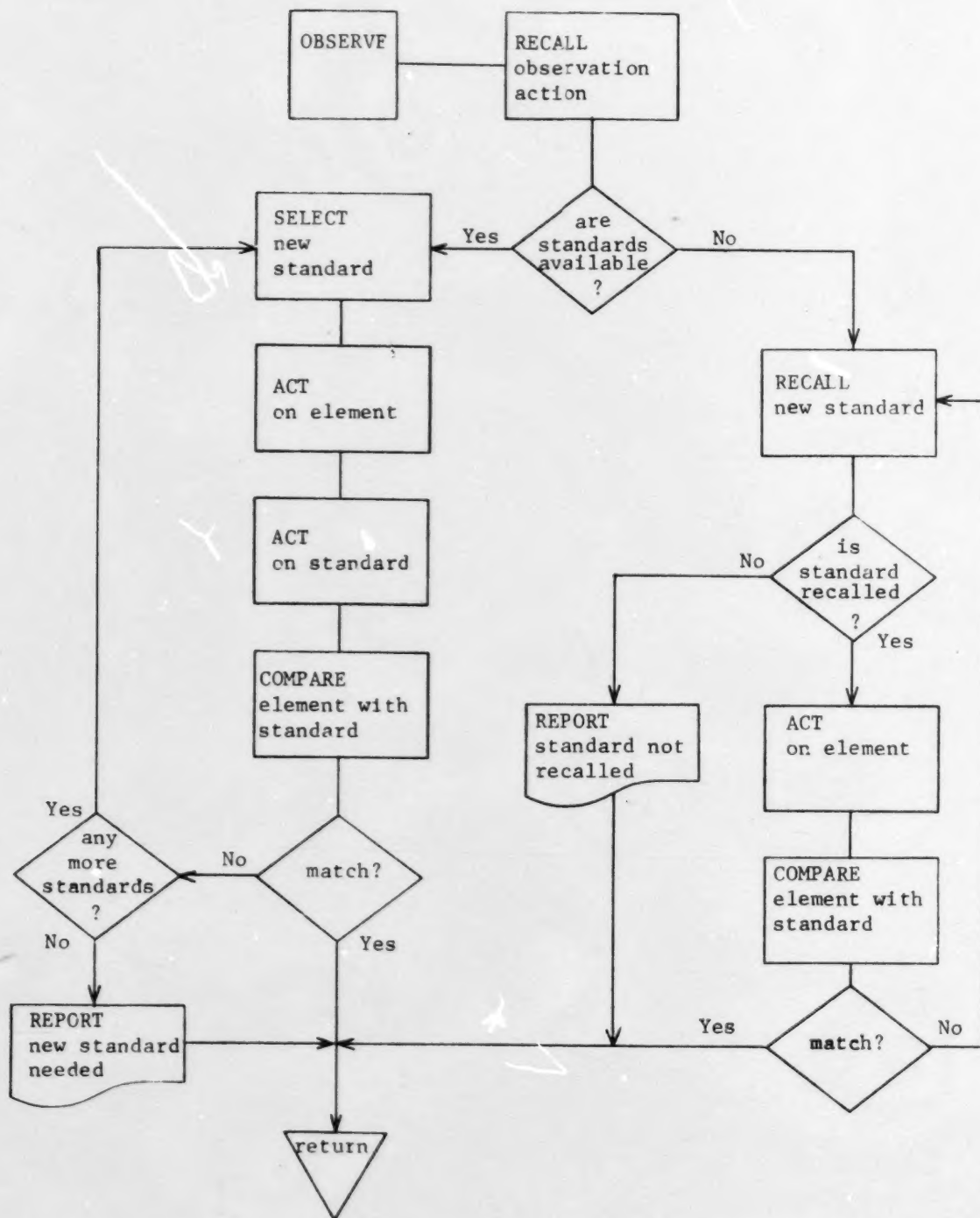


Figure 2. Subroutine for carrying out the observation procedure for a qualitative variable.

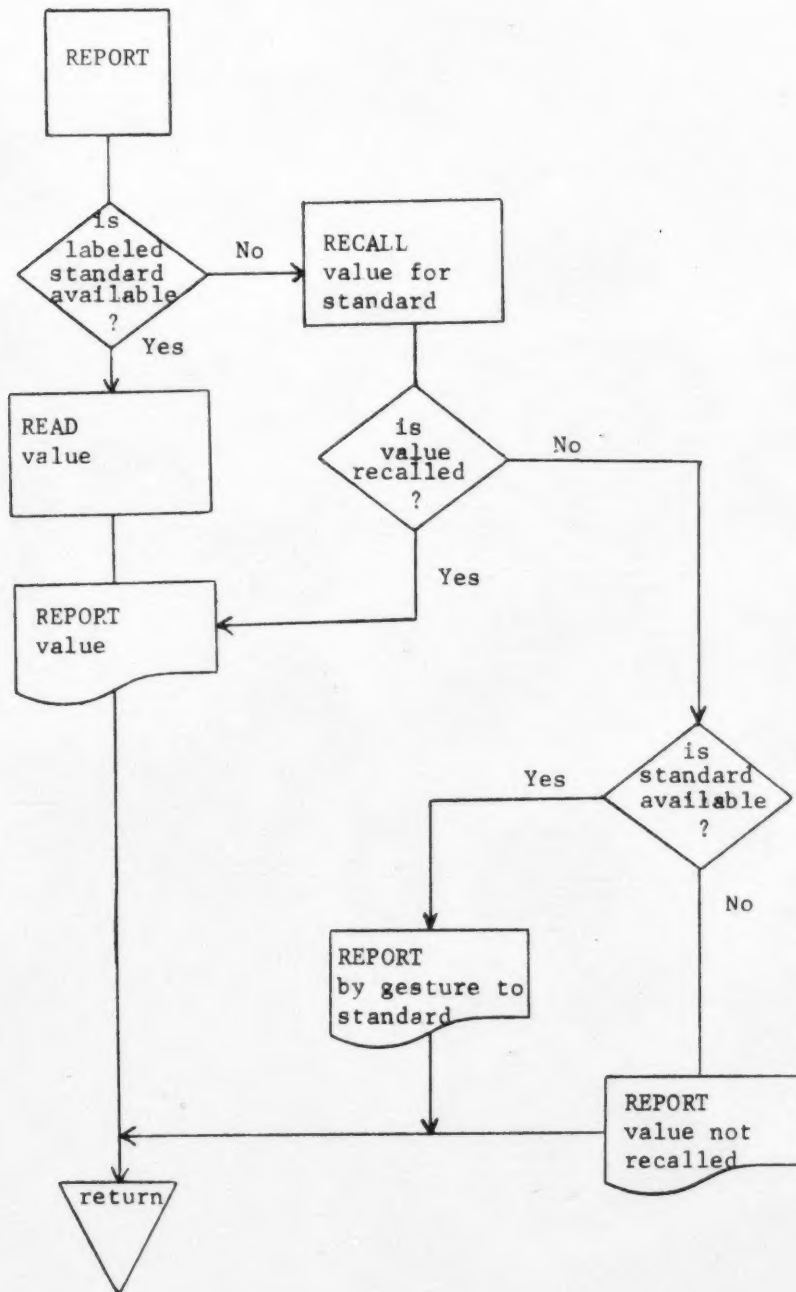


Figure 3. Subroutine for reporting results (values) for a qualitative variable.

name) of this object," is very similar to the nondirected description task with the difference that the variable is a given (rather than being selected by the child) and the element is described only on that variable. As indicated by a comparison of Figures 1 and 4, the processing steps involved in the two tasks are largely the same, with the main difference being that, in the directed description task, the child must decode rather than recall the variable name. The "observe" and "report" subroutines are used in both tasks. Decoding is viewed on the analytic level as a recognition of the kind of network involved and the role of the given component in that network (i.e., understanding that the task is associated with a variable-value network and that the given component is a variable name). Once the variable name is decoded, subroutines executed, and a value on the given variable reported, the directed description task is completed; there is no repeating of the routine, as in the nondirected task.

The element selection task, of the form "Pick out the object which is/has (value)," has as given components a set of elements and a value, and requires an observation/measurement procedure and the selection of an element described by the given value. The routine, diagrammed in Figure 5, involves an initial decoding of the value and identification of the procedure. The basic processes involved in the execution of the procedure are very similar to those required in the nondirected and directed description tasks, (i.e., there is a search which terminates upon a matching of element to standard). The major difference is that instead of comparing one element with

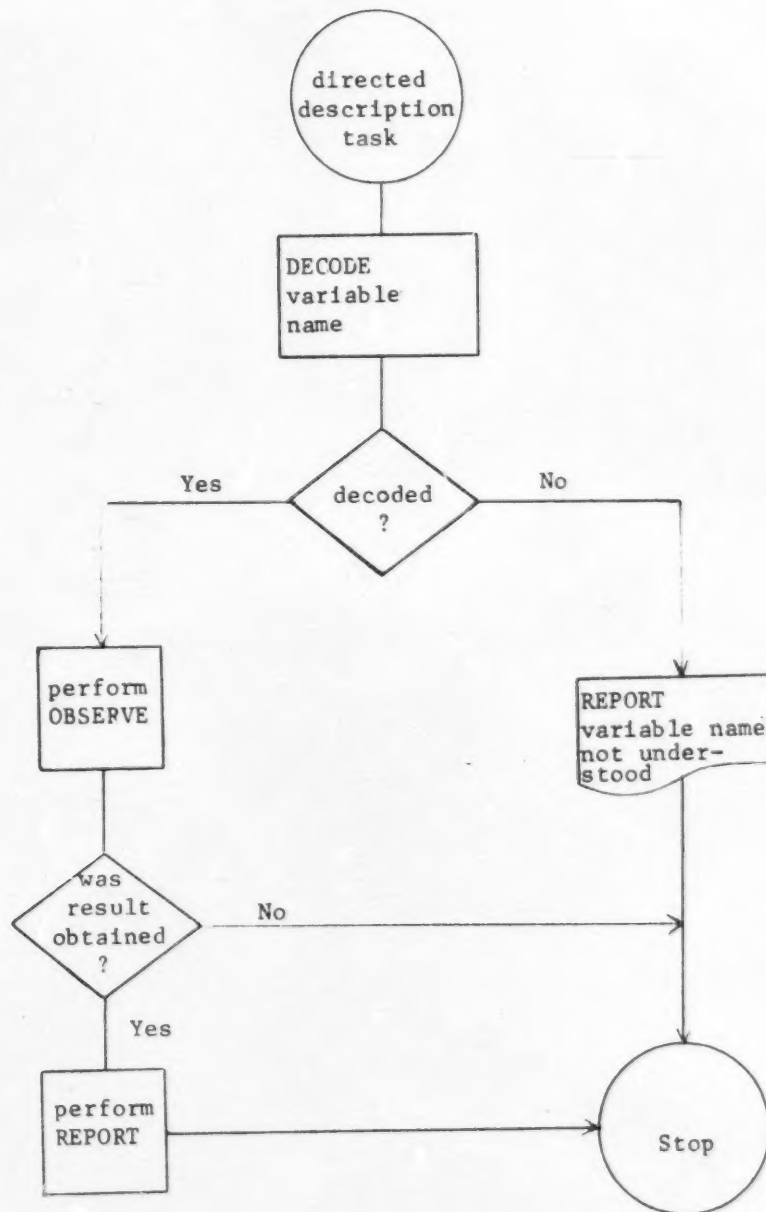


Figure 4. Directed description task processing routine.

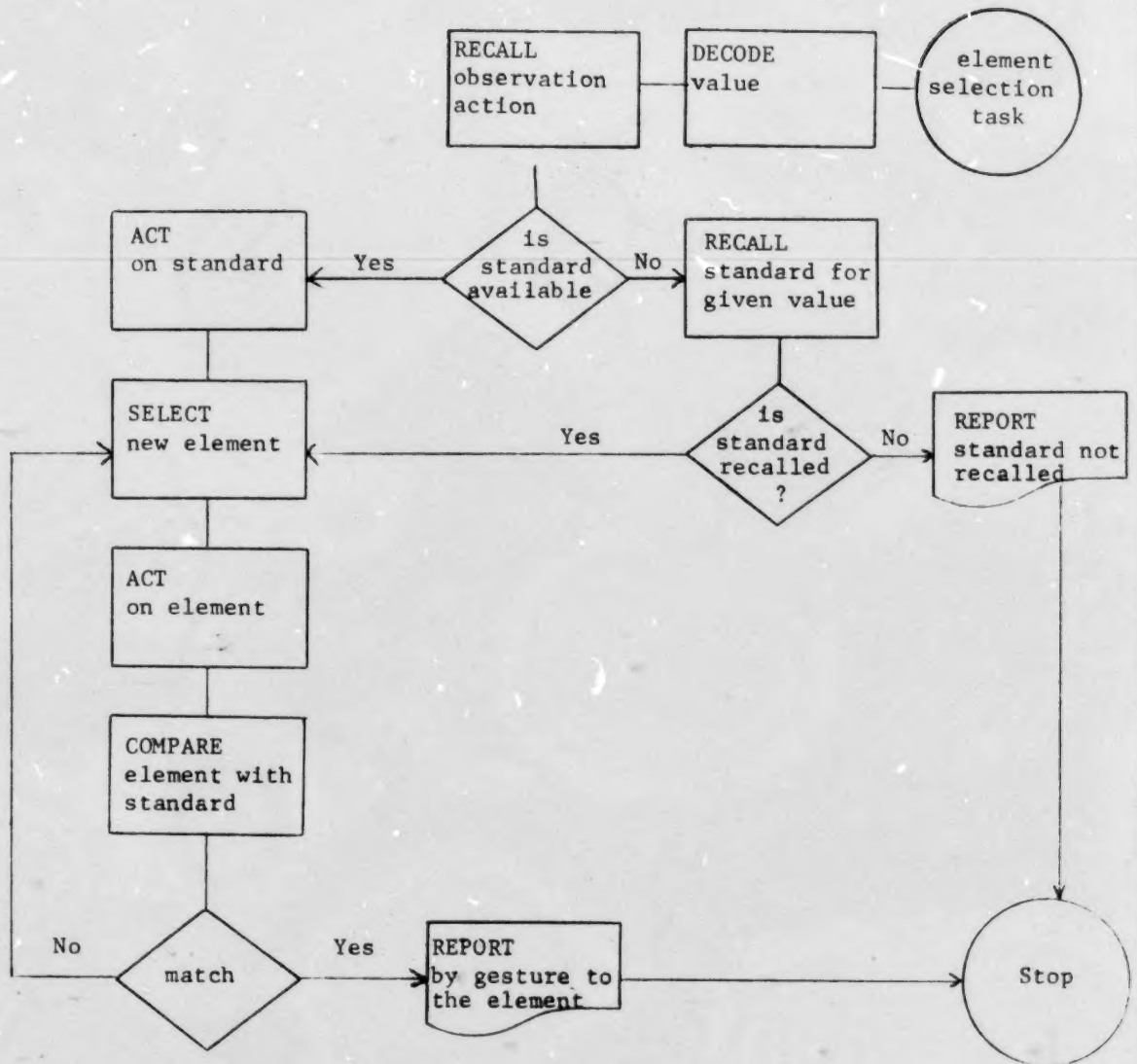


Figure 5. Element selection task processing routine.

more than one standard, the element selection task requires a comparison of the standard with more than one element. Also, since the value is given, the "report" may be simply a gesture to the matching element.

As evident in Figures 1-5, although routines for each description task differ in certain respects, there are many information processing requirements which are common to all three tasks. The processes of decoding and/or reporting variable names and values, recalling and executing an observation action, and comparing element features are invariant. Thus, at least within the limits of the defined area of content, there appears to be a set of basic description tasks which can be carried out by means of common skills.

VARIATIONS IN SYSTEMIC AND PARTICULAR CONTENT

Some distinctions among types of systemic and particular content have important implications for processes and strategies for a given task. The routines discussed above were developed principally in reference to systemic and particular content appropriate at the K-1 level, i.e., the description of simple elements, (e.g., discrete objects) in terms of common qualitative variables whose values are easily observed. Certain types of elements, variables and values will require strategies which deviate at some points with those diagrammed above. The distinction between qualitative and quantitative variables has already been mentioned; for quantitative variables the comparison of an element to standards involves an ordering as well as a matching operation. A subroutine

for carrying out the observation procedure for a quantitative variable where standards are available is diagrammed in Figure 6. Note that another subroutine, "order" (Figure 7) is included in the observation procedure.

The form of the observation/measurement procedure can vary within the same variable as well as between different variables. The procedure described above involves a relatively simple perception of the element. Procedures which require several steps or which utilize measuring instruments necessitate additional and/or alternative operations in the routine.

Distinctions among general classes of elements (objects, constructs, events, symbols, etc.) also have implications for task strategies. For example, the observation/measurement procedure described above applies to concrete elements which can be perceptually encoded--things which can be seen, heard, touched, etc.--rather than to less tangible elements such as events, systems, or constructs whose description presumably involves more complex operations.

In general, while many content distinctions such as those mentioned above are associated with variations in the description routine, these variations appear to be specific and to affect only certain parts of routines or subroutines. For example, in the nondirected description task, quantitative variables or the use of measurement instruments or gauges in the observation/measurement procedure only affect certain segments of the subroutines diagrammed in Figures 2 and 3; the basic description framework as outlined in

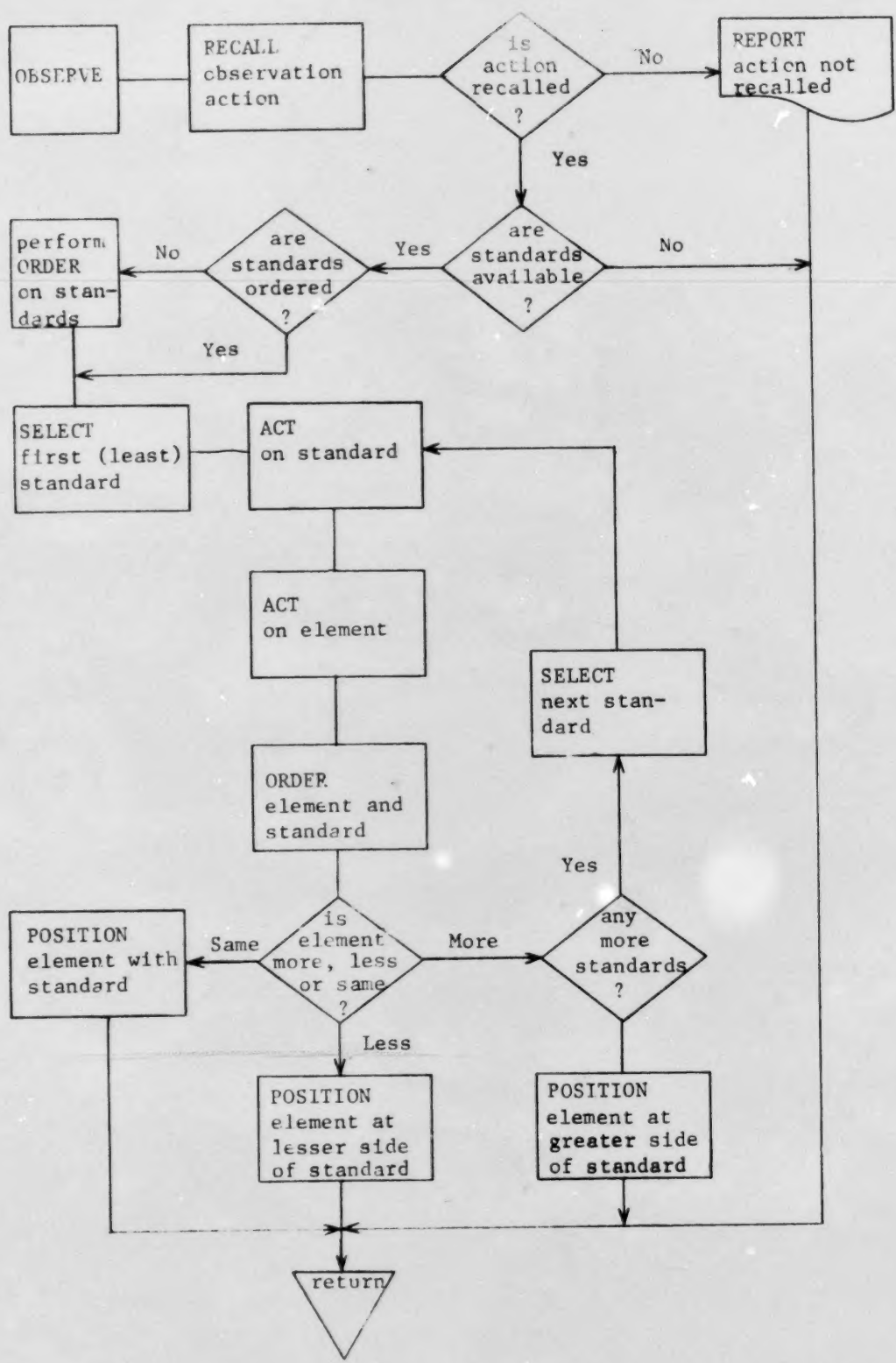


Figure 6. Subroutine for carrying out the observation procedure for a quantitative variable.

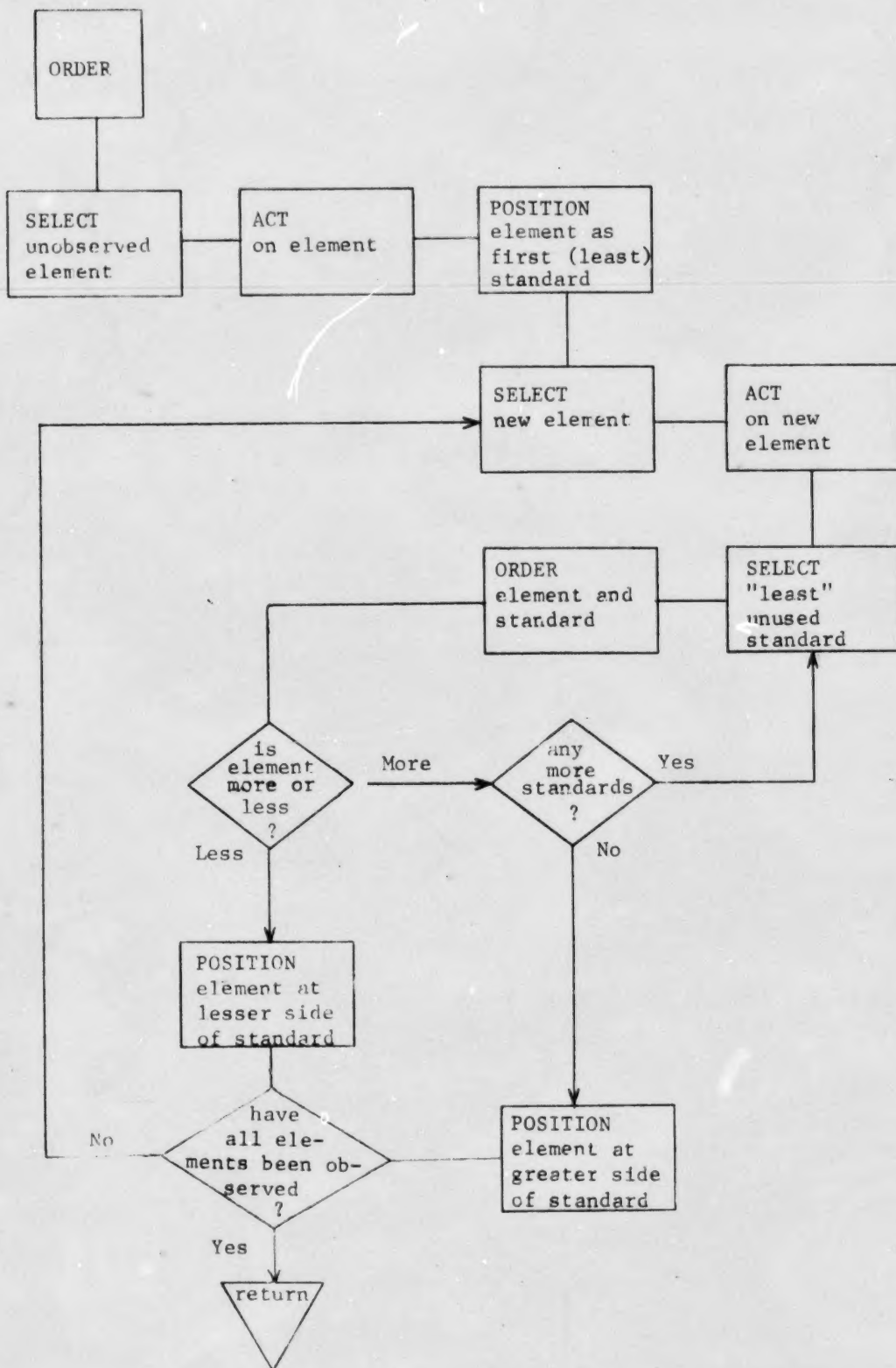


Figure 7. Subroutine for ordering elements (see Figure 6) for a quantitative variable.

Figure 1 remains the same. Although all possible types of content variation have not been analyzed, it appears that the basic structural sequence of the identification of variable and observation/measurement procedures, implementation of the procedure, and reporting of results does not change.

VARIATION WITH PRIOR LEARNING

In addition to changes in the processing steps required to accommodate differing content, the strategy may be modified according to the state of knowledge which has been acquired in relation to a specific systemic network.

The description strategies presented above were designed to permit successful performance of the task based only on a minimal introduction to the components of the variable-value system which is being utilized. After the child has had considerable experience in obtaining values from standards, and applying them to elements, it would be expected that fairly direct associations between the stimulus features, elements and values would be formed. Thus after considerable experience with a variable-value system, the child could be expected to considerably short-circuit the open description strategy, for example, by directly retrieving applicable values from memory and reporting them. After exhausting his supply of known values, he can then return to the basic strategy, taking care not to report values for variables already used.

Quite clearly, it would be possible to propose a somewhat different strategy in which it is assumed that feature-value associations are

rote-learned first, and then used as a basis of description. However, such a strategy would not be nearly as flexible in accommodating modifications or expansions related to content, nor as effective in promoting transfer (i.e., learning-to-learn description tasks). A shortened strategy is inapplicable, for example in the case of a quantitative variable measured through the use of an instrument, regardless of how much experience the child has had with the variable.

FLEXIBILITY OF INFORMATION PROCESSING ANALYSIS

Information processing analysis is important as a tool for identifying a system of processing skills which is sufficient for successful task performance. For a given set of related tasks, the same basic system can be utilized, with variations made upon it when necessary. As noted above, the child need not develop whole new routines to accommodate systemic and particular content of different types and levels of complexity. Instead, existing routines can be made more complete with the addition of new subroutines.

Routines can also be modified so as to reduce the possibility of failure at any particular step in the routine. New subroutines can be added to facilitate recall or decoding of a piece of information or to provide a means of obtaining that information. The following are examples of possible routine modifications.

Various associations may mediate recall of information. In the process of recalling variables for the nondirected description task (see Figure 1), for example, the child may be able to call up associations between sensory modalities and variables

(i.e., by systematically asking himself "What properties can I see, hear, taste, etc."), so that certain variables might be used that otherwise would not have been without this mediating step. This modification of the nondirected description task is diagrammed in Figure 8.

Associations between systemic level components might also be utilized as mediators to facilitate recall. Strengths of associations between systemic level components will vary. For example, for a given individual and a given variable, there may be a stronger association between the observation/measurement procedures and values of the variable than between the procedure and the variable name. For example, in the directed description task (see Figures 2-4), if the child cannot recall the observation/measurement procedure given the name, his recall may be facilitated by recalling values associated with the variable as diagrammed in Figure 9.

In many instances when a child cannot recall a necessary component or perform an operation, steps may be added to the routine to direct him to some resource where he can obtain information necessary to successfully complete that step in the routine, (e.g., the child may go to a resource book, ask a question of his teacher, etc.). An addition to the directed description task which incorporates a simple example of resource seeking is illustrated in Figure 10.

Other types of aids which might be utilized to reduce task failure are of a syntactic nature. In the item form of a given task, clues to the network or the role of a given or required component may be available. For example, in the variable-value network, the syntax

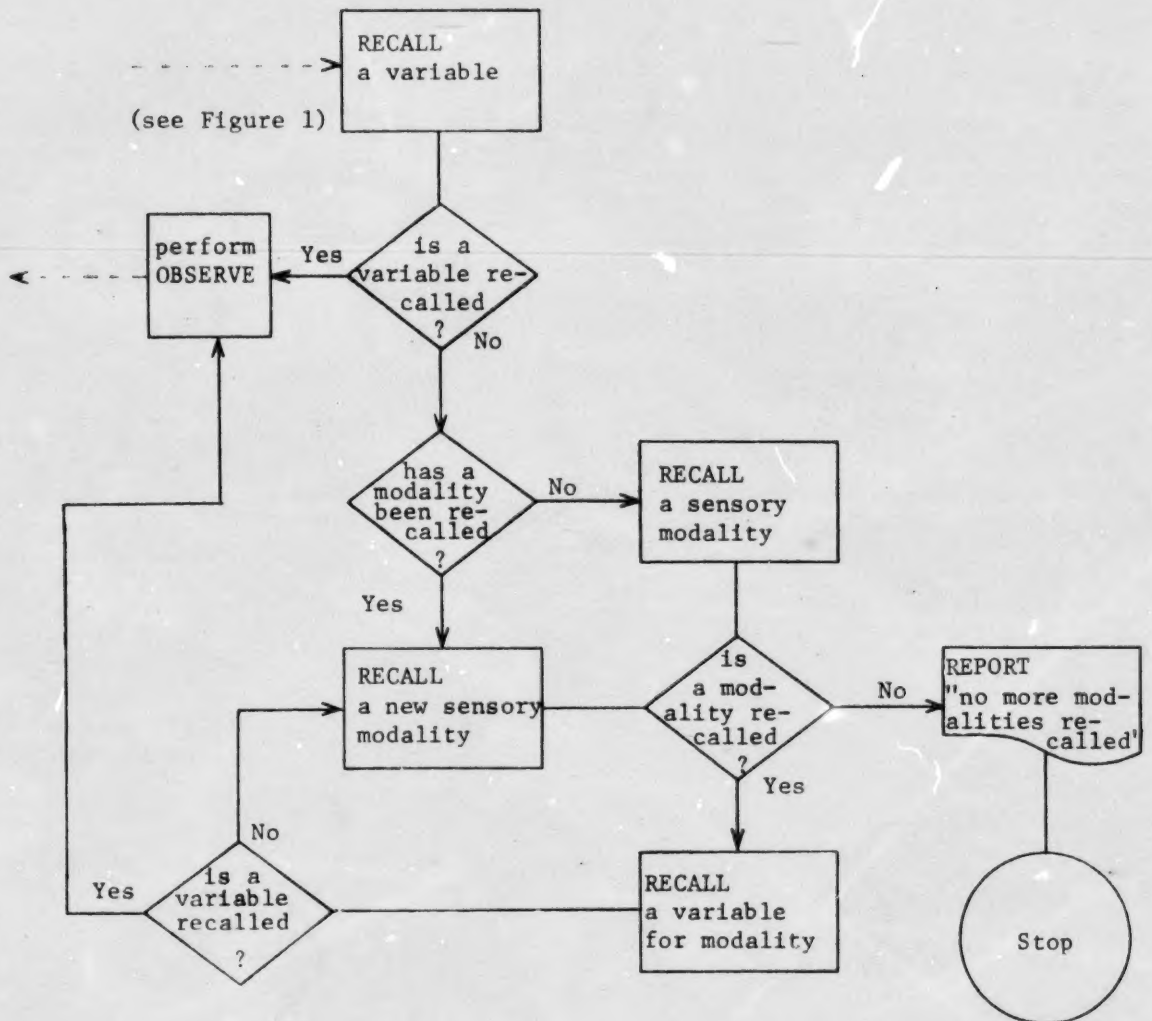


Figure 8. Modification of the nondirected description task routine (Figure 1) where variable recall is mediated by recall of sensory modalities.

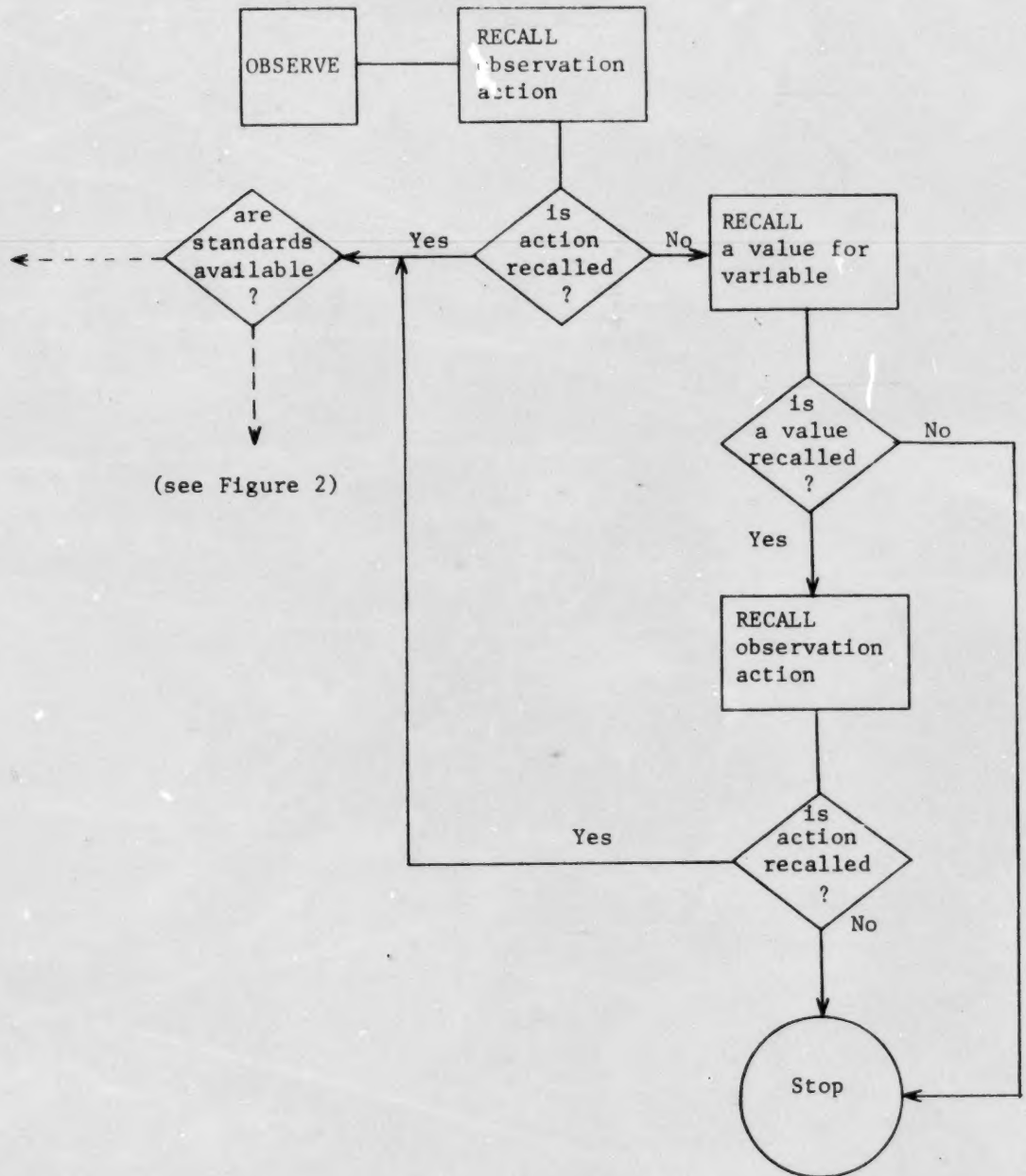


Figure 9. Modification of the OBSERVE subroutine (Figure 2) where recall of an observation action is mediated by recall of values associated with a given variable.

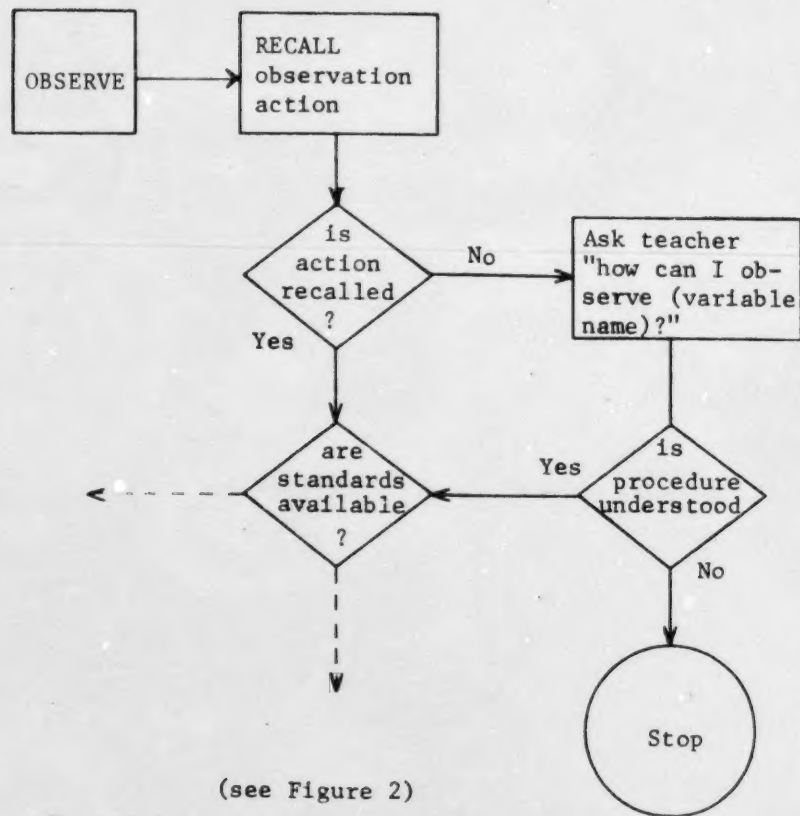


Figure 10. Modification of the OBSERVE subroutine (Figure 2) where an observation action is obtained through an example of resource seeking.

of the item shells, "What is the X of this object" and "Pick out the object which is Y" helps to identify X as a variable name and Y as a value. Thus subroutines which discriminate syntactic structure of item shells might be useful in identifying the task and selecting an appropriate strategy. The analysis of syntax involved in task instructions or verbal responses is important in specifying some aspects of language relevant to instruction in particular disciplines.

PSYCHOLOGICAL INTERPRETATION OF PROCESSING ROUTINES

In the preliminary routines described above, strategies consisting of sequences of processing steps sufficient for successful task performance have been identified. These were not, however, defined precisely in terms of the psychological mechanisms involved. In the second phase of skills analysis, the processing steps are interpreted as specific psychological mechanisms. Thus, the preliminary routines specify the problems which need to be solved by reference to the relevant psychological literature. For example, many of the preliminary routines involve the recalling of certain verbal labels and procedures.

The psychological interpretation of recall steps requires the adoption of hypotheses concerning the nature of the storage of such items in memory and the processes by which they are retrieved. These hypotheses are reflected in the selection and definitions of primary processes in terms of which the final processing routines are defined.

The level of specificity and detail required in the definition of primary processes is itself an hypothesis, at least initially. The adequacy of such hypotheses is judged primarily by the utility of the resulting processing routines, (i.e., by the success of instruction based on them in achieving task mastery and predicted transfer effects). The initial hypothesis is that definition of primary processes in terms of input/output relations is sufficient. The resultant demands to be made on a model of long-term memory in defining primary processes for recall therefore include specification of the nature of the information stored, the kind of information which can be used to gain access to stored information and the major processing steps distinguished.

Frijda (1972) describes a model of long-term memory, some version of which is utilized in nearly all information processing theories and simulations. According to this view, information store is an associative network of items or nodes, each leading to any number of other nodes--the associations of the first node. The stored items or nodes are generally considered to be concepts or ideas themselves rather than names used to refer to them or images exemplifying them. Although this is a somewhat vague position, the important point seems to be that what is stored is not words or images but rather information from which words, images and actions are reconstructed, as proposed by Neisser (1967). Thus, once activated or accessed, a node makes immediately available a number of operational options. Nodes are accessible by way of

other nodes to which they are linked, or by way of items or stimuli that in some sense resemble them (i.e., that resemble some level of reconstruction) or through the decoding of labels that refer to them.

Figure 11 illustrates an associative network which might be drawn upon for performance of tasks such as the directed description task using the processing routine presented in Figure 4. The nodes represent the relevant systemic concepts. In carrying out the directed description task for example, access is acquired to the network through processing the variable name. This involves the decode primary process. Decode takes the variable name as input and, since it activates the "variable X" node in the network, can be said to output the variable X concept. The "output" of a decoding step might perhaps be better termed a result. In effect, the decode process opens the way to many possibilities, but it remains for the next step(s) to take advantage of one or more of them. The possibility that the individual may be set to perform another step which then follows automatically from the decoding need not concern us here. The point is that access to the storage network must be gained as a result of the given variable name. This is the defined function of the decode process.

Although many alternatives processing steps are made possible by the decode process, some directing mechanism insures that access to the observation action node is gained as the next step. This involves the recall primary process. The nature of the directing mechanism has not been further elaborated. At present it seems sufficient to state that this mechanism is capable of directing the recall process to

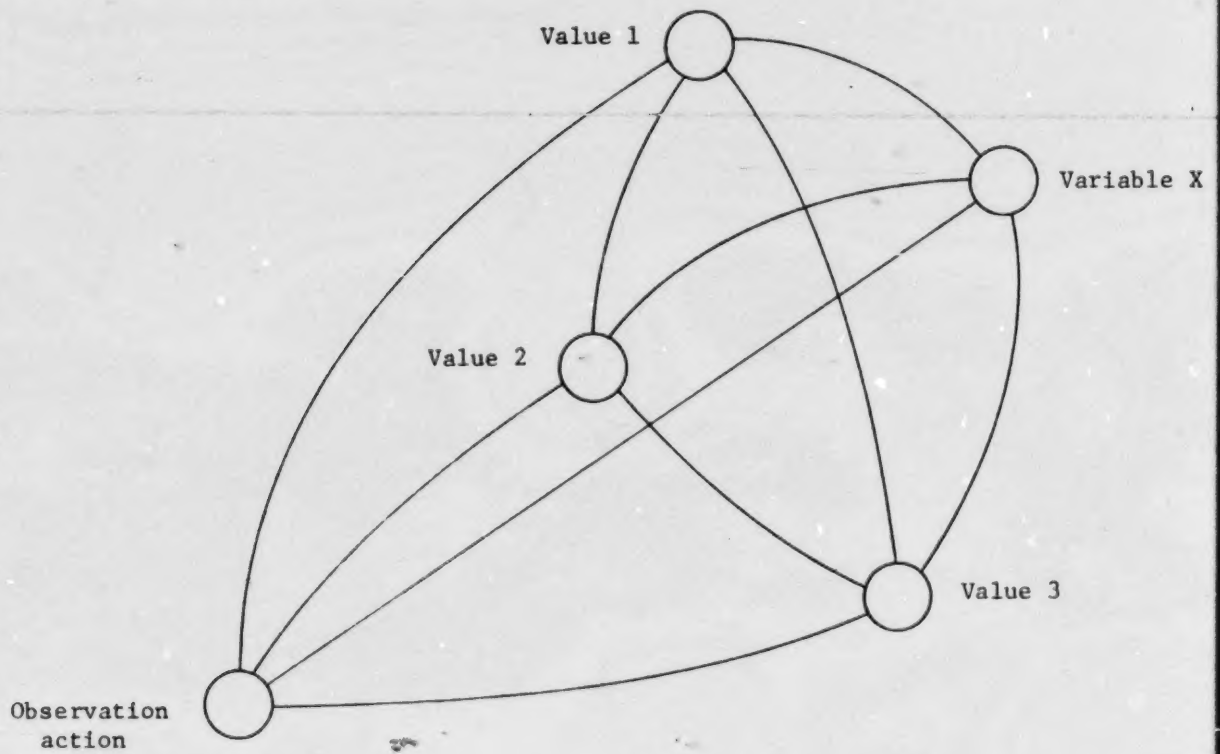


Figure 11. Stored association network for a variable-value conceptual system.

a connected node which is related to the original node in a specific way. Thus, the input of the recall process can be characterized as one concept and its output as another concept. It should be noted that the recall process, just as is the case with the decode process, does not output any images, words or actions.

Once the observation action node has been activated by recall, an action program can be reconstructed which guides the carrying out of an observation action. At present no distinction seems needed between the reconstruction and execution of the action program. Thus, the act primary process implies both. Alternatively, a verbal description of the action could be reconstructed first to mediate the reconstruction and execution of the action program. Both steps represent operational alternatives made available by the activation of the observation action node.

Similar interpretations can be given for each part of the preliminary processing routines based on the relevant psychological literature. The above examples suffice to illustrate the process. The immediate result is a final processing routine for each task and a definition of each primary process involved in them. Subsequent analyses can utilize the primary processes previously defined, thus, the psychological interpretation phase will require less hypothesizing concerning the nature of the processes themselves as more final processing routines are prepared.

An important benefit from the psychological interpretation of the processing steps is the information made available about the

influence of independent variables upon them. Existing knowledge of the effects of such variables can be used in the design of instructional strategies and in studies designed to test hypotheses that particular mechanisms are being employed. Without detailed skills analysis it is impossible to take advantage of such knowledge since there is only the vaguest notion of the processing involved and therefore what literature is relevant.

CONCLUSION

Preliminary processing routines such as those presented in the first sections of the paper specify a strategy for carrying out a task and the general nature of the processing steps required. Thus, applicability to a domain of content can be determined before more detailed analysis is carried out. When their applicability has been judged adequate, further analysis utilizing current knowledge of the relevant psychological processes can be carried out. This stage of analysis recasts the routines in terms of primary processes such as those briefly described in the previous section. These final routines provide the basis for predicting transfer relations among learning outcomes and designing instructional strategies drawing on the relevant psychological literature.

It should be recalled that the information processing strategies which have been presented are not intended as a description of how students actually do perform such tasks. The question of whether these strategies are valid or invalid as descriptions is not relevant. They are conceived as a description of one feasible, and reasonably efficient way of performing such tasks, and as being trainable by some

instructional procedures. The relevant criteria for evaluation include: 1) can instructional procedures be devised which result in acquisition of the intended strategies in a reasonable segment of instructional time, 2) is the strategy effective, when carried out, in producing valuable behavior, and 3) are the processing routines useful in predicting transfer relations among related learning events. Whether or not the intended strategy is a valid description of behavior is a relevant question only in relation to children who have received instruction designed to produce the strategy.

REFERENCES

- Bessemer, D. W., & Smith, E. L. The role of skills analysis in instructional design. Technical Note No. TN-2-72-50, Southwest Regional Laboratory, Los Alamitos, California.
- Frija, N. H. Simulation of human long term memory. *Psychological Bulletin*, 1972, 77(1), 1-31.
- Neisser, U. *Cognitive psychology*. New York: Appleton-Century-Crofts, 1967.
- Smith, E. L. Analytic networks and task domains for a primary grade science curriculum. Technical Note No. TN-2-72-51, Southwest Regional Laboratory, Los Alamitos, California.

DISTRIBUTION

1 - Babikian
1 - Briggs
1 - Coker
1 - Colton
5 - CRC Heads - Design
5 - Directorate
1 - Follettie
1 - Lester (In the SWRL)
12 - Library
1 - Perkins
1 - Piper
1 - Rudegeair
1 - Rundle
10 - 202 Staff